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Weiser et al.

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(54) **SYSTEMS AND METHODS FOR PROVIDING A CLIENT-SIDE APPLICATION PROGRAMMING INTERFACE TO ACCESS A NETWORKED TELECOMMUNICATION RESOURCE**

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G06F 15/16 (2006.01)

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USPC **719/317**; 719/328; 709/202; 709/203

(58) **Field of Classification Search**
USPC 719/310, 317, 328; 709/202, 203
See application file for complete search history.

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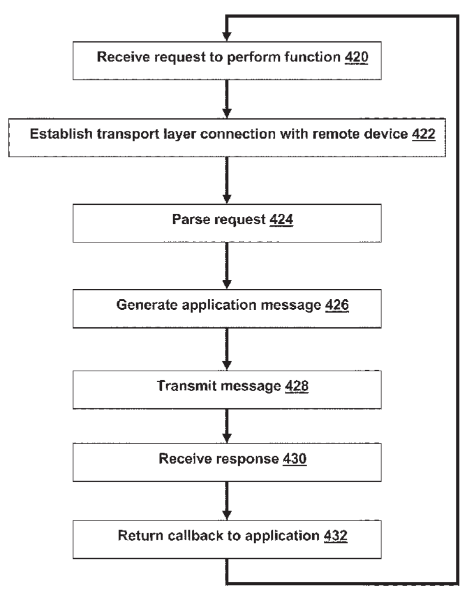
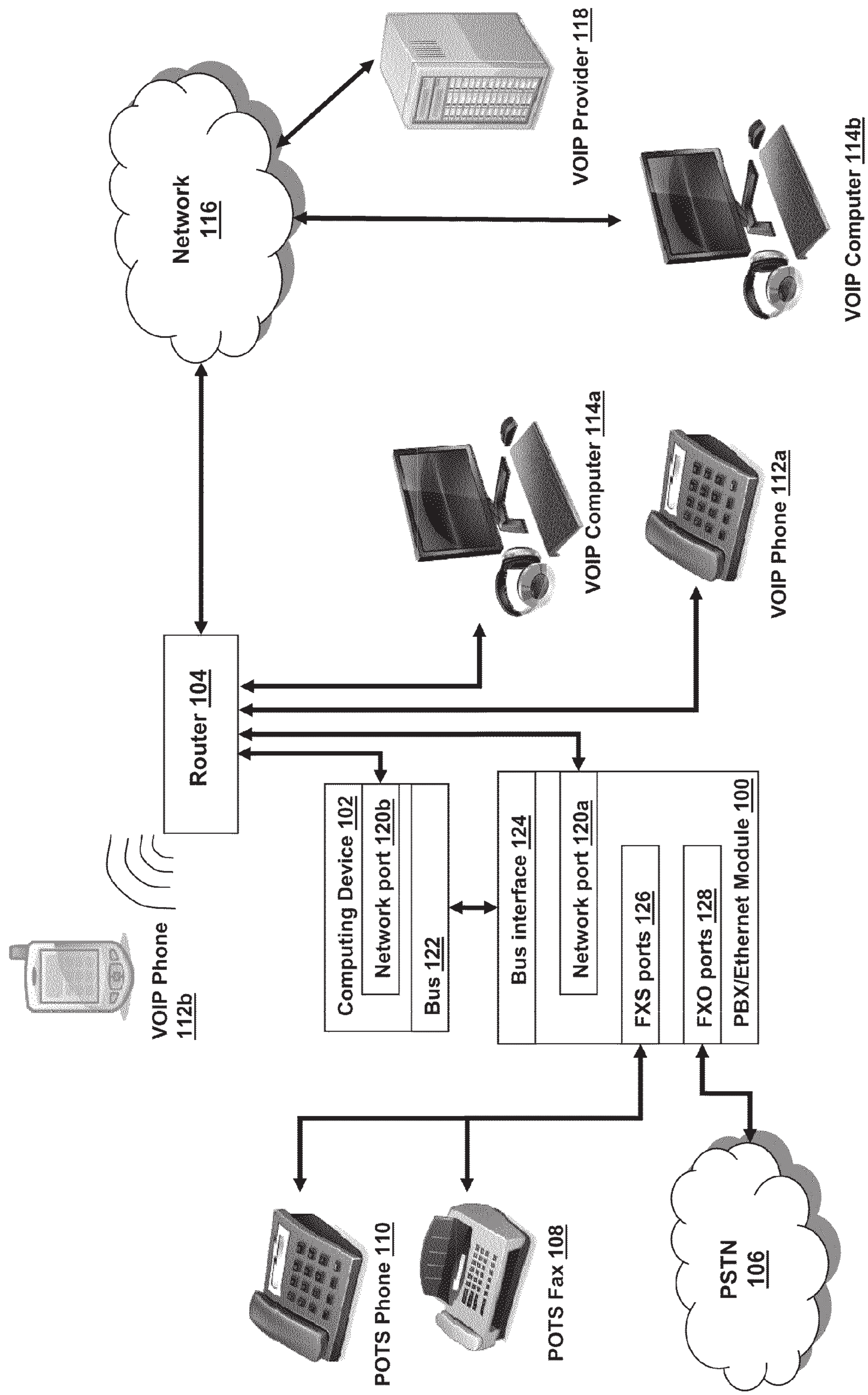
(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP; Christopher J. McKenna

(57) **ABSTRACT**

The present application is directed towards systems and methods for interfacing a network-agnostic application to a networked telecommunication resource. An agent executing on a client receives a request from an application in the form of an API function call and establishes a connection to a networked telecommunications resource. The agent handles network processing of the request, a response or responses, and asynchronous events, and translates them into corresponding API callbacks for use by the application.

21 Claims, 11 Drawing Sheets





Network
116
VOIP Provider 118
VOIP Computer 114b
Router 104
VOIP Computer 114a
VOIP Phone 112a
VOIP Phone
112b
Computing Device 102
Network port 120b
Bus 122
Bus interface 124
Network port 120a
FXS ports 126
FXO ports 128
PBX/Ethernet Module 100
POTS Phone 110
POTS Fax 108
PSTN
106

FIG. 1A

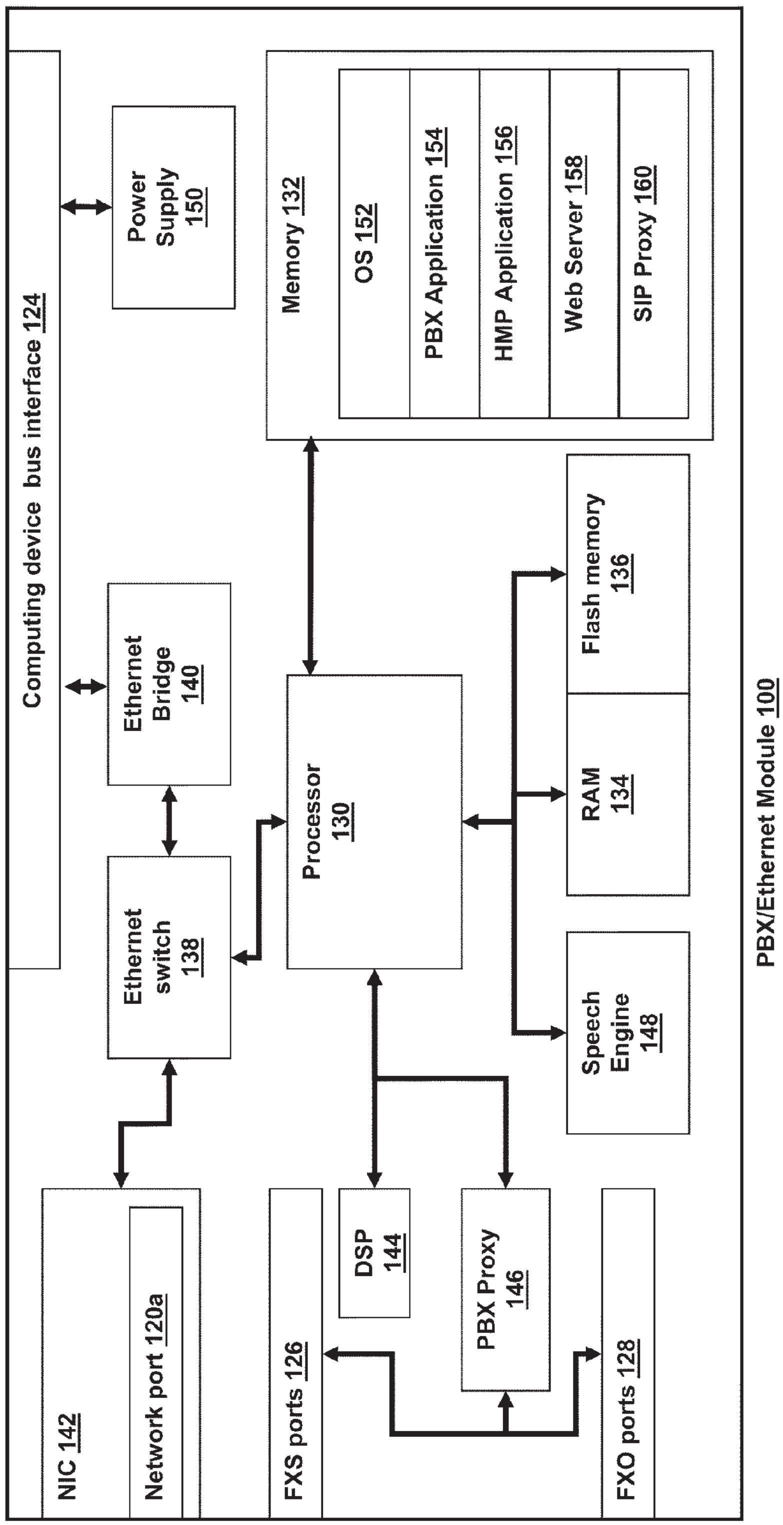

Computing device bus interface 124
Power Supply 150
Memory 132
OS 152
PBX Application 154
HMP Application 156
Web Server 158
SIP Proxy 160
Ethernet Bridge 140
Ethernet switch 138
Processor 130
Flash memory 136
RAM 134
Speech Engine 148
NIC 142
Network port 120a
FXS ports 126
DSP 144
PBX Proxy 146
FXO ports 128
PBX/Ethernet Module 100

FIG. 1B

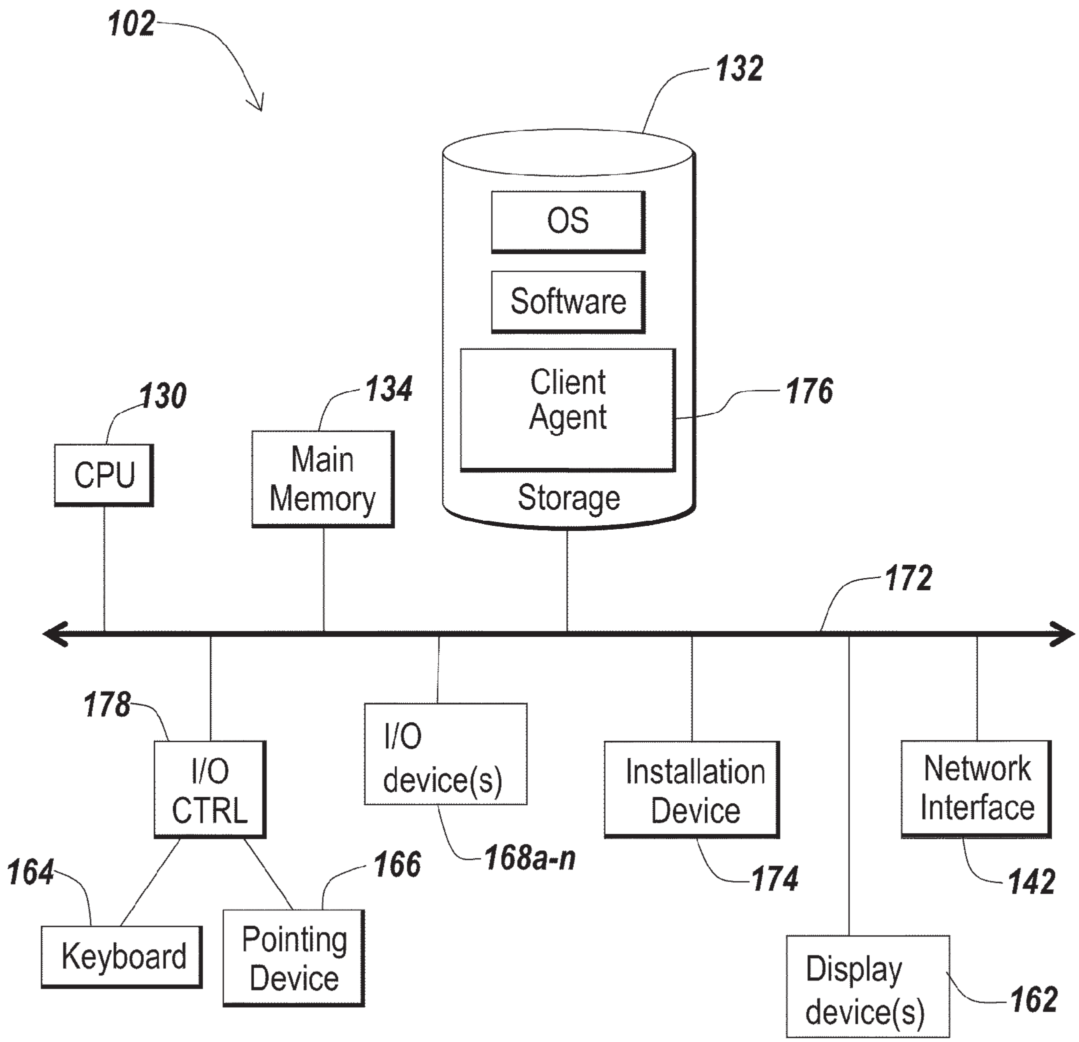

102
132
OS
Software
Client Agent
176
Storage
130
CPU
134
Main Memory
172
178
I/O CTRL
I/O device(s)
168a-n
Installation Device
174
Network Interface
142
164
Keyboard
Pointing Device
166
Display device(s)
162

FIG. 1C

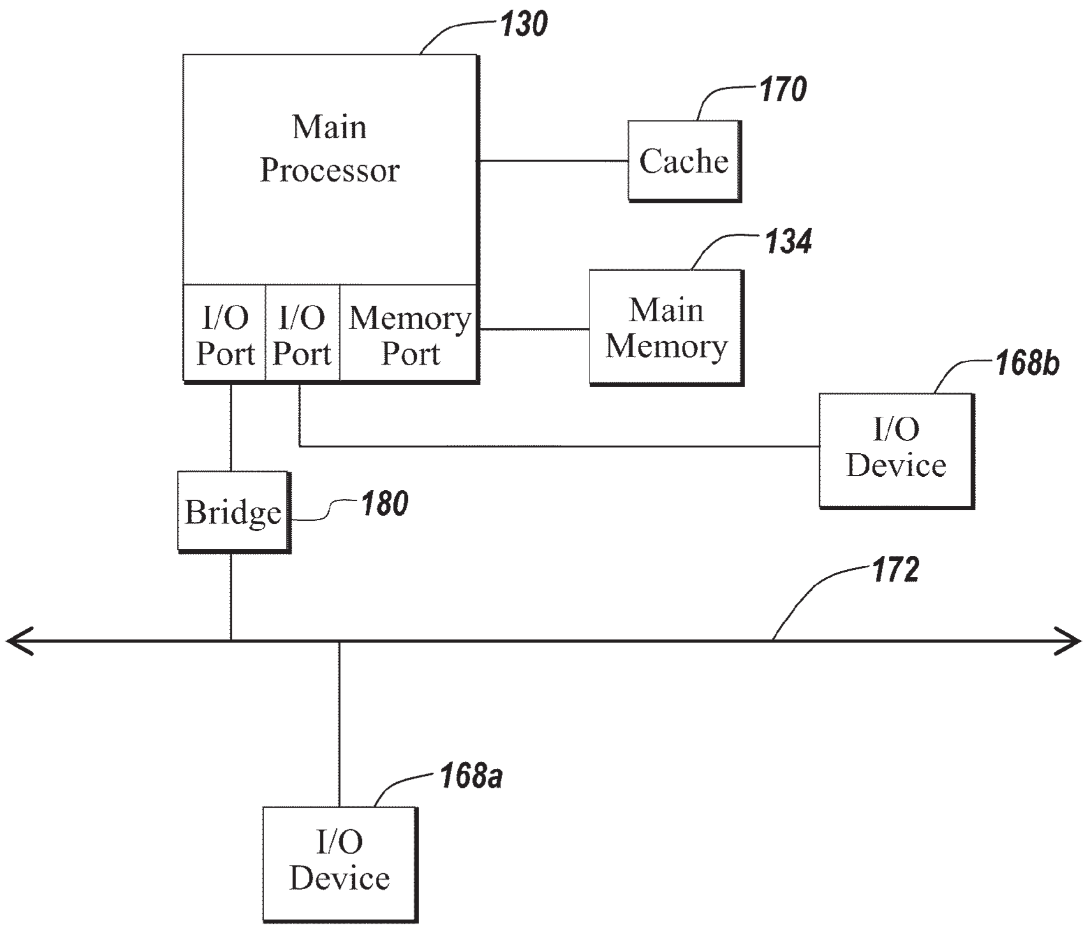

130
Main
Processor
170
Cache
134
Main
Memory
I/O
Port
I/O
Port
Memory
Port
168b
I/O
Device
Bridge
180
172
168a
I/O
Device

FIG. 1D

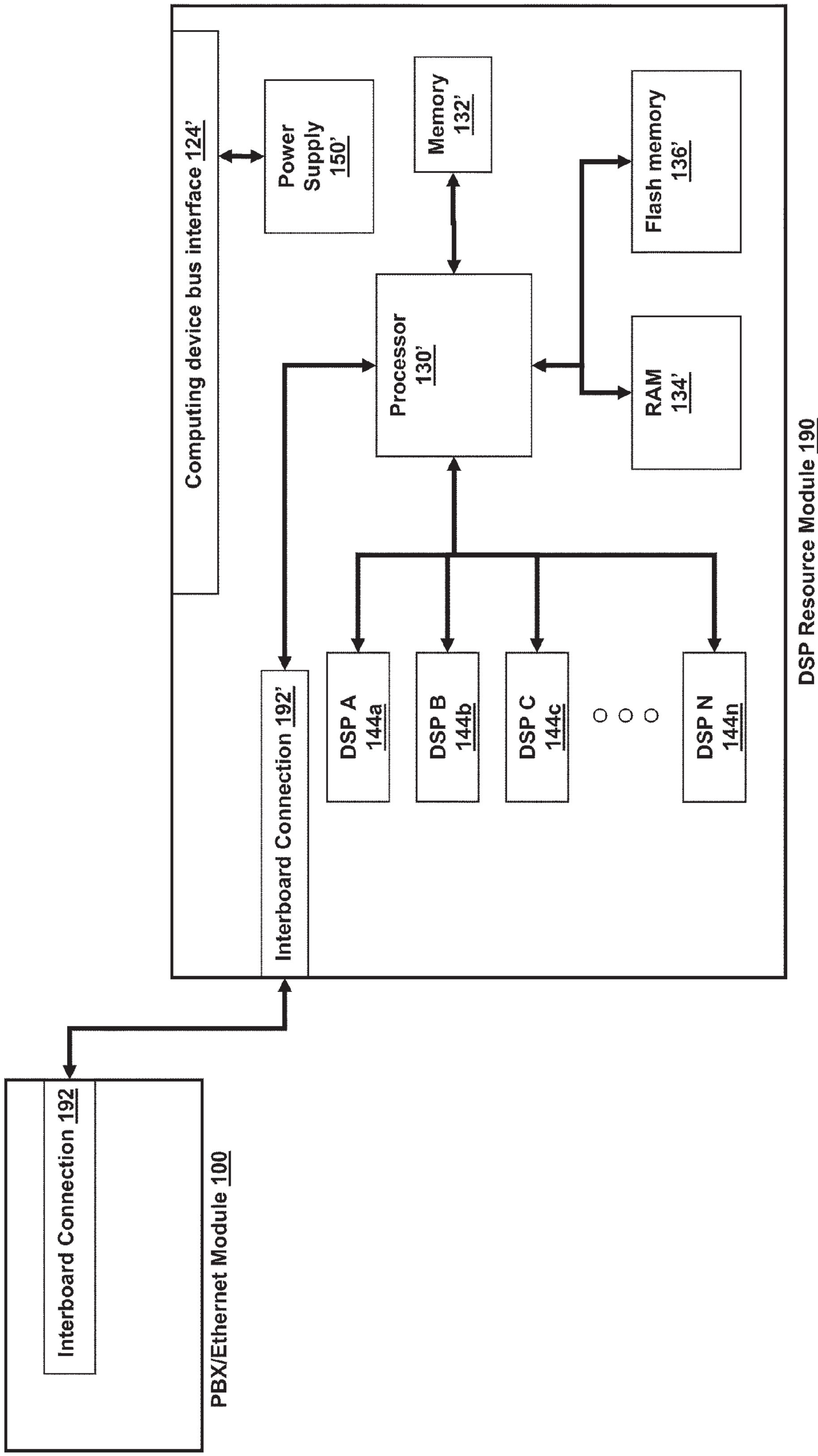

Computing device bus interface 124'
Power Supply 150'
Memory 132'
Flash memory 136'
Processor 130'
RAM 134'
Interboard Connection 192'
DSP A 144a
DSP B 144b
DSP C 144c
DSP N 144n
DSP Resource Module 190
Interboard Connection 192
PBX/Ethernet Module 100

FIG. 1E

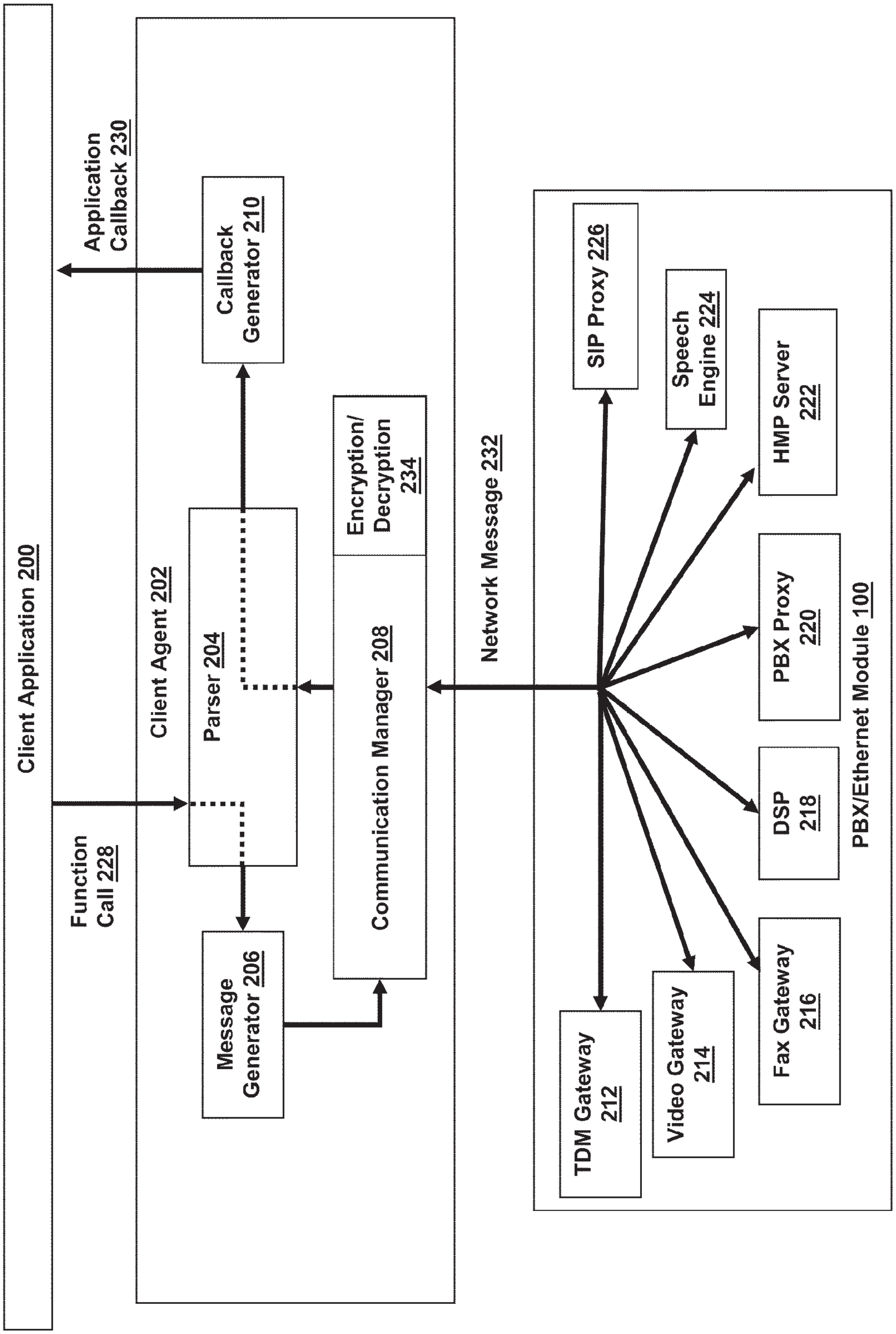

Client Application 200
Application Callback 230
Function Call 228
Client Agent 202
Callback Generator 210
Parser 204
Message Generator 206
Encryption/ Decryption 234
Communication Manager 208
Network Message 232
SIP Proxy 226
Speech Engine 224
HMP Server 222
PBX Proxy 220
DSP 218
Fax Gateway 216
Video Gateway 214
TDM Gateway 212
PBX/Ethernet Module 100

FIG. 2

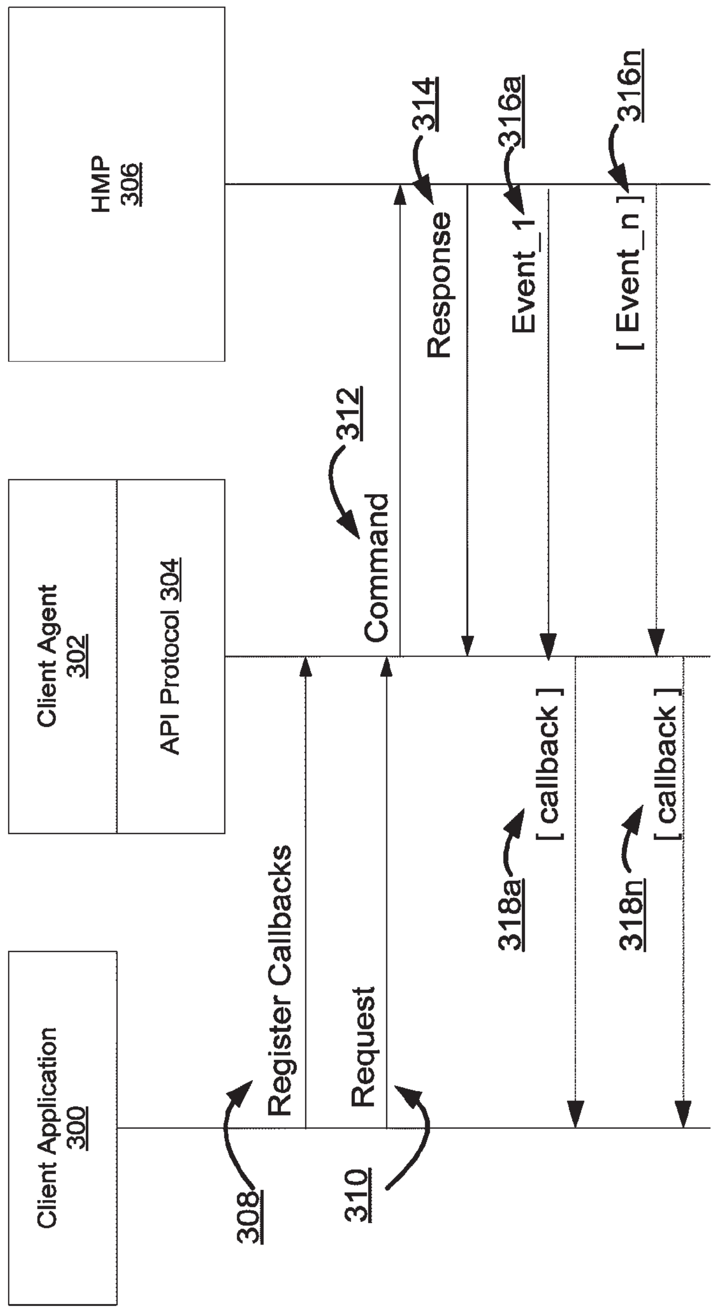

Client Application 300
Client Agent 302
API Protocol 304
HMP 306
308
Register Callbacks
310
Request
312
Command
314
Response
316a
Event_1
316n
[Event_n]
318a
[callback]
318n
[callback]

FIG. 3A

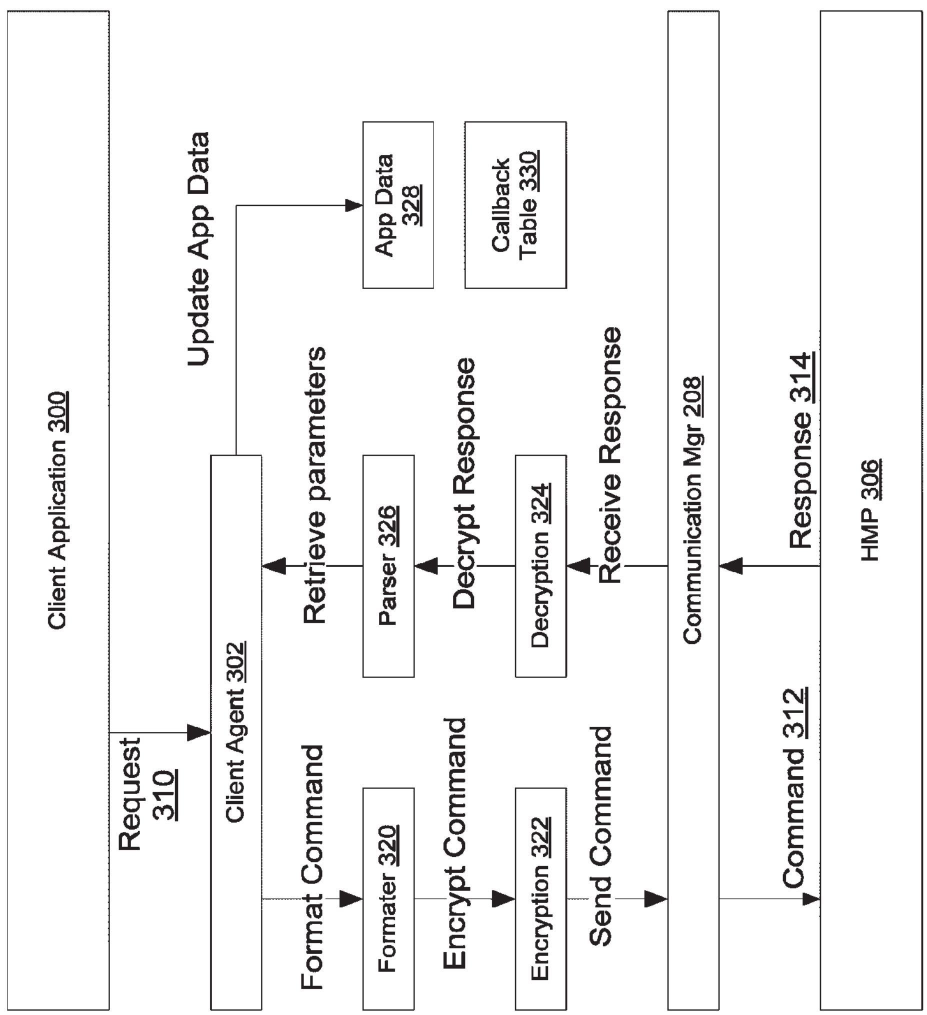
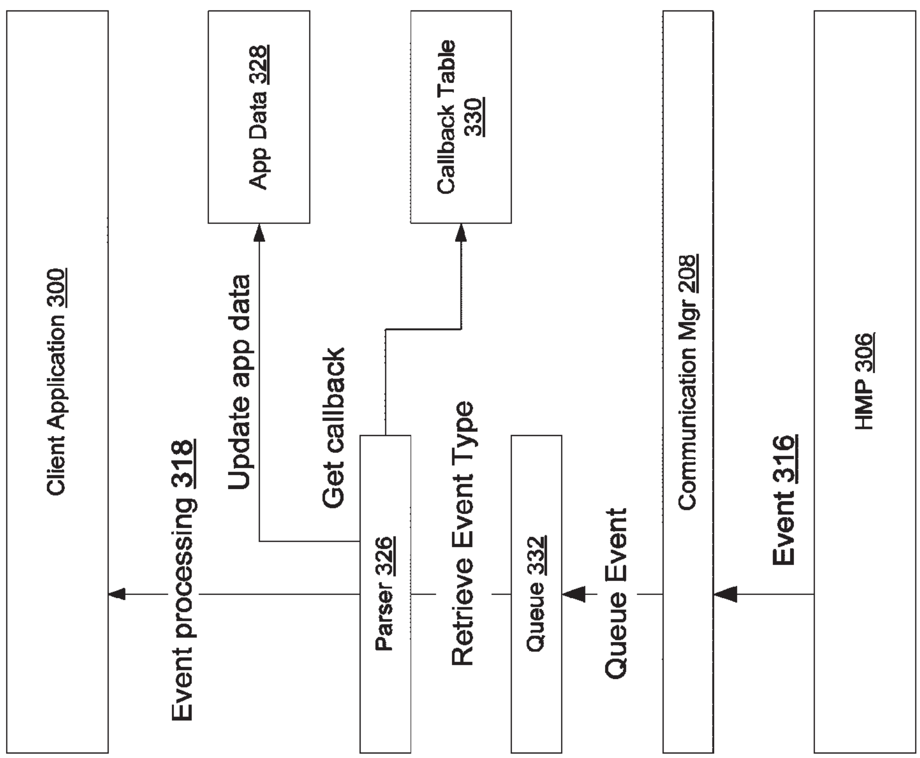

Client Application 300
Request 310
Client Agent 302
Update App Data
App Data 328
Callback Table 330
Format Command
Formater 320
Retrieve parameters
Parser 326
Encrypt Command
Encryption 322
Decrypt Response
Decryption 324
Send Command
Receive Response
Communication Mgr 208
Command 312
Response 314
HMP 306

FIG. 3B



Client Application 300
App Data 328
Callback Table 330
Communication Mgr 208
HMP 306
Event processing 318
Update app data
Get callback
Parser 326
Retrieve Event Type
Queue 332
Queue Event
Event 316

FIG. 3C

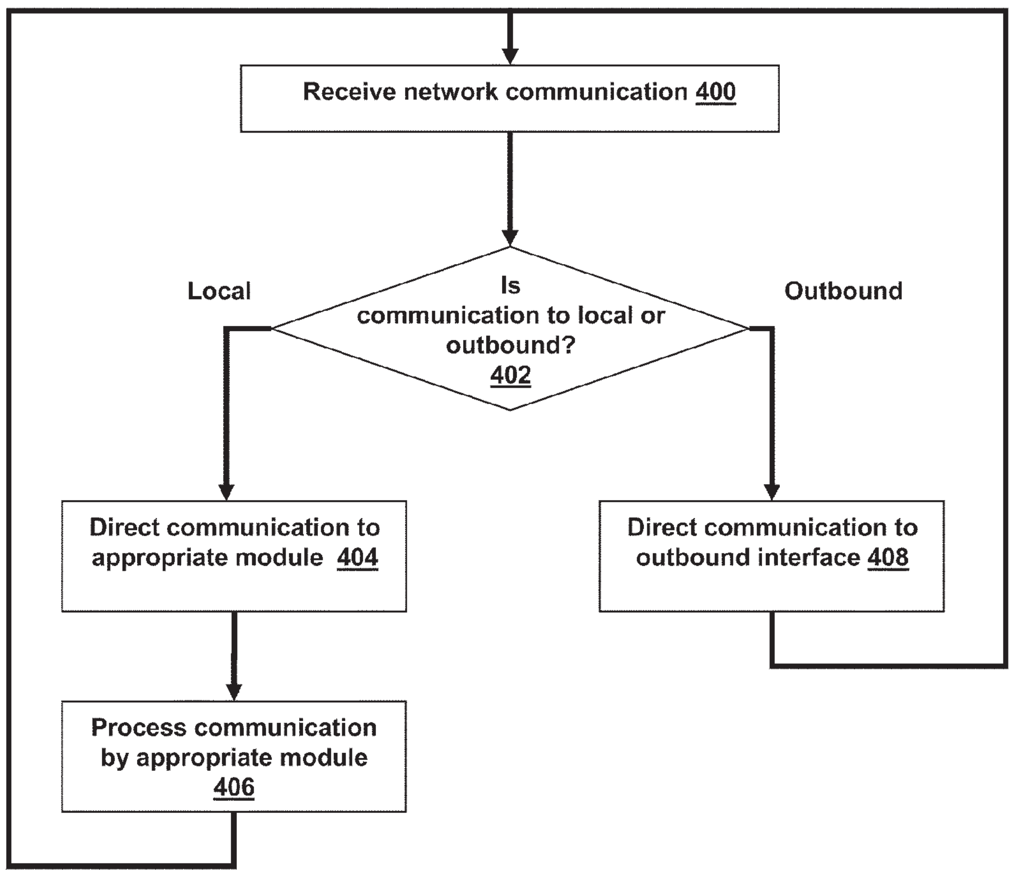

Receive network communication 400
Local
Is communication to local or outbound? 402
Outbound
Direct communication to appropriate module 404
Direct communication to outbound interface 408
Process communication by appropriate module 406

FIG. 4A

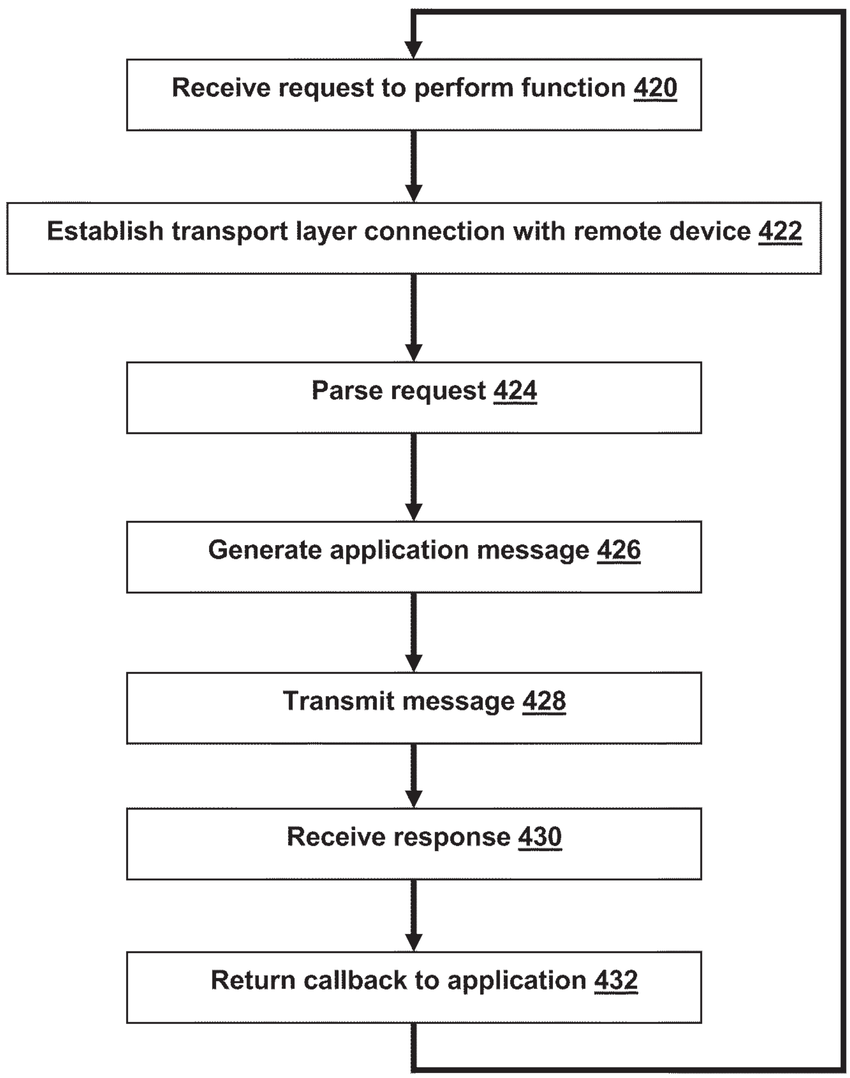

Receive request to perform function 420
Establish transport layer connection with remote device 422
Parse request 424
Generate application message 426
Transmit message 428
Receive response 430
Return callback to application 432

FIG. 4B

SYSTEMS AND METHODS FOR PROVIDING A CLIENT-SIDE APPLICATION PROGRAMMING INTERFACE TO ACCESS A NETWORKED TELECOMMUNICATION RESOURCE

FIELD OF THE INVENTION

The present application generally relates to telecommunications networks. In particular, the present application relates to systems and methods for interfacing a network-agnostic application to a networked telecommunication resource.

BACKGROUND OF THE INVENTION

Business and Personal communications are diversifying away from the traditional phone-to-phone call model, and are instead being replaced by multi-user communications such as conference calls, video conference calls, fax being delivered by email, voice being communicated over Session Initiation Protocol (SIP) or Voice over Internet Protocol (VoIP) and other new tools. While these different technologies and applications all converge on the user's PC, the systems used to deliver and control these applications are different. There have been no simple and standard systems that application developers may use to create an application which will unite the command, control and communication over a single API interface.

BRIEF SUMMARY OF THE INVENTION

The present application is directed towards systems and methods for interfacing a network-agnostic application to a networked telecommunication resource. An agent executing on a client receives a request from an application in the form of an API function call and establishes a connection to a networked telecommunications resource. The agent handles network processing of the request, a response or responses, and asynchronous events, and translates them into corresponding API callbacks for use by the application.

In one aspect, the present application features a method for providing a client-side application programming interface to access a networked telecommunication resource. The method includes an agent executing on a client device receiving, via a local application interface call from a client application, a request to perform a function via a telecommunication resource. The method also includes the client agent establishing a transport layer connection via a network to the remote device identified by the agent as providing the telecommunication resource. The method further includes the client agent generating an application message corresponding to the local application interface call. The method also includes the client agent transmitting the application message over the transport layer connection via the network to the remote device. The method also includes the client agent receiving a response to the application message via the network from the telecommunication resource of the remote device. The method further includes the client agent returning a result to the local application interface call based on the response.

In some embodiments, the method includes the client agent receiving a local API call from a client application that is not network aware. In other embodiments, the method includes the client agent determining a network identifier for the telecommunication resource identified by the local application interface call.

In some embodiments, the method includes the client agent generating for the application message an ASCII message from parameters of the local API call. In other embodiments, the method includes the client agent encrypting the application message.

In one embodiment, the method includes the client agent transmitting the application message via a telecommunications protocol over the transport layer connection to the remote device. In another embodiment, the method includes the client agent parsing an application layer payload of the response to extract parameters. In still another embodiment, the method includes the client agent decompressing an application layer payload of the response.

In some embodiments, the method includes the client agent determining from content of an application layer payload of the response the result to return to the local API call. In other embodiments, the method includes the client agent receiving an event via application layer data from one or more packets transmitted by the remote device to the agent. In still other embodiments, the method includes the client agent transmitting the application message and receiving the response via the network transparently to the client application.

In another aspect, the present application features a system for providing a client-side application programming interface to a telecommunication. The system includes an agent executing on a client device receiving via a local application interface call from a client application a request to perform a function via a telecommunication resource. The system also includes a formatter of the agent formatting an application message corresponding to the local application interface call. The system further includes a communications manager of the agent establishing a transport layer connection via a network to the remote device identified by the agent as providing the telecommunication resource and transmitting the application message over the transport layer connection via the network to the remote device, and wherein the communications manager receives a response to the application message via the network from the telecommunication resource of the remote device. The system also includes a parser of the agent parses the response received from the communication manager, and wherein the agent returns a result to the local application interface call based on the parsed response.

In one embodiment, the system includes the agent, responsive to a plurality of local API calls and transparently to the client application, transmitting requests to one or more telecommunication resources over the network and receiving responses over the network from the one or more telecommunication resources. In another embodiment, the system includes the communications manager determining a network identifier for the telecommunication resource identified for the local application interface call. In still another embodiment, the system includes the formatter generating for the application message an ASCII message from parameters of the local API call.

In another embodiment, the system includes an encryptor of the agent encrypting the application message. In still another embodiment, the system includes a protocol manager transmitting via the communications manager the application message via a telecommunications protocol over the transport layer connection to the remote device. In yet another embodiment, the system includes the parser parsing an application layer payload of the response to extract parameters. In still another embodiment, the system includes a decryptor decompressing an application layer payload of the response.

In some embodiments, the system includes a protocol manager determining from content of an application layer payload of the response the result to return to the local API call. In other embodiments, the system includes an events manager receiving from the communications manager an event via

application layer data of one or more packets transmitted by the remote device and responsive to the event, the events manager executing one or more callbacks registered for the event.

The details of various embodiments of the invention are set forth in the accompanying drawings and the description below.

BRIEF DESCRIPTION OF THE FIGURES

The foregoing and other objects, aspects, features, and advantages of the invention will become more apparent and better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1**A is a block diagram of an embodiment of a mixed switched and IP telecommunications environment;

FIG. **1**B is a block diagram of an embodiment of an interface module for a mixed switched and IP telecommunications environment;

FIGS. **1**C-**1**D are block diagrams of embodiments of a computing device;

FIG. **1**E is a block diagram of an embodiment of a DSP resource module;

FIG. **2** is a block diagram of an embodiment of a system for communicating with an interface module for a mixed switched and IP telecommunications environment;

FIG. **3**A is a signal flow diagram of an embodiment of an application programming interface (API) between a client application and a host media processing (HMP) system;

FIG. **3**B is a block diagram of an embodiment of an API between a client application and an HMP system;

FIG. **3**C is another block diagram of an embodiment of an API between a client application and an HMP system;

FIG. **4**A is a flow chart of an embodiment of a method for accessing private branch exchange services via a single integrated device installed as an Ethernet adapter on a computing device; and

FIG. **4**B is a flow chart of an embodiment of a method for providing a client-side application programming interface to access a networked telecommunication resource.

The features and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings, in which like reference characters identify corresponding elements throughout. In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements.

DETAILED DESCRIPTION OF THE INVENTION

Prior to discussing the specifics of embodiments of the systems and methods of the present solution, it may be helpful to discuss the network and computing environments in which such embodiments may be deployed. Shown in FIG. **1**A is a block diagram of an embodiment of a mixed switched and IP telecommunications environment. In brief overview, a PBX/Ethernet module **100** interfaces with a switched network such as a public switched telephone network (PSTN) **106** via a foreign exchange office (FXO) port or ports **128**. The PBX/Ethernet module **100** also interfaces with switched telecommunications devices, including a post office telephone service (POTS, also referred to as a post office telephone system or a plain old telephone system) fax machine **108**, and a POTS phone **110**, via a foreign exchange service (FXS) port or ports **126**. The PBX/Ethernet module **100** also interfaces with a computing device **102** via a bus interface **124** to a bus **122**. The PBX/Ethernet module and computing device **102** interface with an Ethernet network via a router **104**, to communicate with devices and networks including voice-over-internet-protocol (VOIP) phones **112***a* and **112***b* (which may connect wirelessly to a wireless router **104**), VOIP computers **114***a* and **114***b*, a network **116**, and a VOIP provider **118**. Although FIG. **1**A shows a network **106** between the VOIP provider **118** and VOIP computer **114***b* and router **104**, in some embodiments, the VOIP provider **118** and VOIP computer **114***b* may be on the same network as router **104**. In some embodiments, devices connected to router **104**, such as VOIP phones **112***a* and **112***b*, computing device **102**, PBX/Ethernet module **100**, and VOIP computer **114** may be referred to as comprising a local area network (LAN) or a private area network. Although not illustrated, in some embodiments, one or more additional network segments may exist between devices, phones, and computers connected to router **104**.

Still referring to FIG. **1**A and in more detail, in some embodiments, a PBX/Ethernet module **100** may comprise one or more network ports **120***a*, one or more FXS ports **126**, and one or more FXO ports **128**. The PBX/Ethernet module **100** may also include a bus interface **124** for interfacing with a computing device **102**. In many embodiments, a PBX/Ethernet module **100** serves as an interface between a switched network, such as a PSTN network **106** and a packet network, such as a private area network or local area network via a hardware interface such as Ethernet. In many embodiments, a PBX/Ethernet module **100** may also serve as a controller for a private branch exchange (PBX) network. PBX/Ethernet module **100** is also described in more detail below in connection with FIG. **1**B.

A computing device **102** may comprise a client, a workstation, a server, a blade server, an appliance, or any other computing device that comprises a bus **122** capable of interacting with a bus interface **124** of a PBX/Ethernet module **100**. In many embodiments, a computing device **102** may supply power to a PBX/Ethernet module **100** via bus **122** and bus interface **124**. For example, in one embodiment in which bus **122** is a PCI bus and bus interface **124** is a PCI interface, a computing device **102** may supply power to PBX/Ethernet module **100** from a power supply unit of computing device **102** via the bus. In some embodiments, bus **122** and bus interface **124** may comprise an VESA VL bus, an ISA bus, an EISA bus, a MicroChannel Architecture (MCA) bus, a PCI bus, a PCI-X bus, a PCI-Express bus, a NuBus, or any similar bus capable of carrying power to PBX/Ethernet module **100**. In many embodiments, bus **122** and bus interface **124** may allow communication between computing device **102** and PBX/Ethernet module **100**, as described in more detail below.

In some embodiments, router **104** may comprise a router, a switch, a network hub, a wireless router, a LAN management appliance, a network address translator, a gateway, multi-port firewall, or any other type of computing or network device for routing data packets amongst a plurality of computing devices, IP phones, or other network devices or segments. Router **104** may connect to various devices via Ethernet, firewire, or other hardware interfaces, or via wireless interfaces, such as **802.11***a*, **802.11***b*, **802.11***g*, **802.11***n*, Wimax, or any other wireless or RF interface. In some embodiments, router **104** may connect to a PBX/Ethernet module **100** via a network port **120***a* and/or a computing device **102** via a network port **120***b*. Network ports **120***a* and **120***b* may comprise Ethernet or firewire ports or other hardware interfaces, or wireless transmitters and receivers capable of interfacing with a wireless interface of router **104**.

In some embodiments, PSTN **106** may comprise any type and form of a public switched telephone network, or connec-

tion thereto, or other circuit switched network provided by a telephone company or other service provider. Connection from PSTN **106** to PBX/Ethernet module **100** may be via one or more FXO ports **128**, and may be via analog or digital interfaces, including POTS trunk lines, ISDN, T1, E1, or any other interface for connecting one or more PSTN trunks to a private branch exchange switch. In some embodiments, POTS devices, such as a POTS fax machine **108** or a POTS phone **110** may connect via a foreign exchange service (FXS) port or ports **126** on PBX/Ethernet module **100** to the PSTN network **106**.

In some embodiments, a voice-over-IP (VOIP) provider **118** may provide VOIP services to one or more components of the system, including VOIP computers **114***a* and **114***b*, a wired VOIP phone **112***a*, and a wireless VOIP phone **112***b*. In many embodiments, VOIP provider **118** interfaces with these components via a network **116**, which may be a wide area network, including the Internet, a metropolitan area network, a public network, a private network, a virtual private network, or any other type and form of network. In some embodiments, VOIP provider **118** may be located on a local area network or private network and connected directly to router **104**. VOIP provider **118** may provide voice and/or video routing, incoming call signaling, outgoing call dialing, encryption, conference calling, voice mail, and other VOIP features to VOIP phones **112** and VOIP computers **114** running software VOIP interfaces.

Referring now to FIG. **1**B, illustrated is a block diagram of an embodiment of a PBX/Ethernet device, also referred to as module **100**. In brief overview, in some embodiments, a PBX/Ethernet module **100** may comprise a processor **130**, a memory element **132**, a random access memory element **134**, a flash memory interface or element **136**, an Ethernet switch **138**, an Ethernet bridge **140**, and a network interface card **142**. In some embodiments, PBX/Ethernet module **100** may also comprise a digital signal processor **144** and/or a private branch exchange proxy **146**. PBX/Ethernet module **100** may also comprise FXS ports **126** and FXO ports **128**, discussed above in connection with FIG. **1**A. In many embodiments, PBX/Ethernet module **100** may comprise a speech engine **148**. In some embodiments, PBX/Ethernet module **100** may comprise a power supply **150**, connected to a bus interface **124**.

As shown, a PBX/Ethernet module **100** may comprise interfaces for both a packet-based network, such as Ethernet switch **138**, Ethernet bridge **140**, and NIC **142**; and a circuit-switched network, such as FXS ports **126**, FXO ports **128**, and PBX proxy **146**. In some embodiments, a PBX/Ethernet module **100** serves as a bridge or interface between these two networks, allowing interoperability and flexibility of deployment. In many embodiments, PBX/Ethernet module **100** operates in a stand-alone fashion, executing an operating system **152** and applications **154-160** on processor **130**, using power supplied via the bus interface **124** from a computing device **102**, and distributed via an on-board power supply **150**. By including a processor, memory, and operating system independent of those of computing device **102**, PBX/Ethernet module **100** has enhanced reliability and stability, requiring, in some embodiments, only power from computing device **102**. In other embodiments, an external power supply may be connected to PBX/Ethernet module **100**, such that computing device **102** is not necessary for operation.

Still referring to FIG. **1**B and in more detail, in some embodiments, a PBX/Ethernet module **100** may comprise a processor **130**, which may be referred to as a central processing unit or CPU, a processor, a microprocessor, or any similar notation. Processor **130** may comprise any type and form of processing unit, including: those manufactured by Intel Corporation of Mountain View, Calif.; those manufactured by Motorola Corporation of Schaumburg, Ill.; those manufactured by Transmeta Corporation of Santa Clara, Calif.; the RS/6000 processor, those manufactured by International Business Machines of White Plains, N.Y.; or those manufactured by Advanced Micro Devices of Sunnyvale, Calif.; or any other processor capable of executing the functions described herein.

Although much of the functionality described in more detail below, such as an HMP application **156**, a speech engine **148**, a PBX Proxy **146**, etc., are recited as being executed or performed by processor **130**, in many embodiments, a co-processor, not illustrated, may execute or perform part or all of these functions, to off-load processing from the primary processor **130**. Similarly, in some embodiments, functions described as being executed or performed by a co-processor may be executed or performed by processor **130**. Furthermore, in some embodiments, processor **130** may comprise a multi-core processor or may comprise multiple processors collectively referred to as processor **130**. Thus, one skilled in the art may readily appreciate that one or more processors and/or co-processors may perform or execute any of the functionality described herein.

In some embodiments, processor **130** may be connected via one or more internal busses to a memory element **132** and random access memory **134**. Memory element **132** may comprise flash memory, a hard drive, or any other data storage element capable of storing data in a manner accessible and editable by processor **130**. Memory **132** may comprise one or more of an operating system **152**, a PBX application **154**, a host media processing (HMP) application **156**, a web server **158**, and a session initiation protocol (SIP) proxy **160**. RAM **134** may comprise one or more memory chips capable of storing data and allowing any storage location to be directly accessed by processor **130**, such as Static random access memory (SRAM), Burst SRAM or SynchBurst SRAM (BSRAM), Dynamic random access memory (DRAM), Fast Page Mode DRAM (FPM DRAM), Enhanced DRAM (EDRAM), Extended Data Output RAM (EDO RAM), Extended Data Output DRAM (EDO DRAM), Burst Extended Data Output DRAM (BEDO DRAM), Enhanced DRAM (EDRAM), synchronous DRAM (SDRAM), JEDEC SRAM, PC100 SDRAM, Double Data Rate SDRAM (DDR SDRAM), Enhanced SDRAM (ESDRAM), SyncLink DRAM (SLDRAM), Direct Rambus DRAM (DRDRAM), or Ferroelectric RAM (FRAM). In some embodiments, RAM **134** may comprise a cache memory.

In some embodiments, a PBX/Ethernet module **100** may include a flash memory interface **136**. The flash memory interface **126** may comprise and type and form of interface constructed and designed for receiving, accessing or reading flash memory media or devices, such as a the common flash memory interface (CFI). In many embodiments, flash memory interface **136** may be used for loading new operating systems **152** or applications **154-160** onto a PBX/Ethernet module **100**. For example, a user may insert a flash memory card into interface **136** and restart the PBX/Ethernet module **100**, triggering an initialization sequent to load new software from the flash memory card.

A network interface card or NIC **142** may comprise one or more network ports **120***a*, as discussed above in connection with FIG. **1**A. In many embodiments, a NIC **142** serves as an Ethernet network interface for PBX/Ethernet module **100**. The NIC **142** can in some embodiments be any of the network interface cards or mechanisms described herein. The NIC **552** can have any number of ports. The NIC may be designed and

constructed to connect to any type and form of network or router **104**. While a single NIC **142** is illustrated, the PBX/Ethernet module **100** may comprise any number of NICs **142**.

The NIC **142** may, in some embodiments, interact with an Ethernet switch **138**. Ethernet switch **138** may comprise any combination of hardware and software elements for routing communications between a NIC **142**, a processor **130**, and an Ethernet bridge **140**. For example, a PBX/Ethernet module **100** may receive communications from a computing device **102** via a bus interface **124**, as discussed above. In some instances, these communications may be directed to processor **130**, such as control or configuration commands for any of applications **154-160**. In other instances, these communications may be directed outward to a network, via NIC **142**. Similarly, incoming communications from a network via NIC **142** may be directed to processor **130**, or to a computing device **102** via the bus interface **124**. Thus, the functions of Ethernet switch **138** allows the PBX/Ethernet module **100** to serve as a NIC for both applications of PBX/Ethernet module **100** and for computing device **102**.

In some embodiments, an Ethernet bridge **140** serves to bridge a layer **2** network from Ethernet switch **138** to a computing device **102** via bus interface **124**. An Ethernet bridge **140** may comprise any combination of hardware and software elements for connecting and managing network segments at the data link layer. In many embodiments, Ethernet bridge **140** further includes functionality to appear as a NIC or virtual NIC to computing device **102**. For example, in some embodiments, upon installation of a PBX/Ethernet module **100** into a computing device **102**, Ethernet bridge **140** may appear as an installed NIC or Ethernet adapter to computing device **102**, such that applications and protocols above the link layer may communicate via the PBX/Ethernet module **100**. In some embodiments, no additional software drivers need be installed on computing device **102** to allow for Ethernet communications via PBX/Ethernet module **100**. In one embodiment, an Ethernet switch **138** and/or Ethernet bridge **140** provide network address translation or port forwarding and provide distinct network addresses to one or more components of the PBX/Ethernet module **100**, including a web server **158**, HMP application **156**, PBX application **154**, speech engine **148**, PBX proxy **147**, SIP proxy **160**, or any other component. In a further embodiment, Ethernet switch **138** and/or Ethernet bridge **140** provide a distinct network address to a host computing device **102** via a bus interface **124**. In one such embodiment, PBX/Ethernet module **100** may be installed as an Ethernet adapter on computing device **102** and direct communications to a first IP and port to computing device **102**, and communications to a second IP and port to components of PBX/Ethernet module **100**. For example, PBX/Ethernet module **100** may direct communications to IP 1.2.3.4 to a host computing device **102** via the bus interface **124**, and direct communications to IP 1.2.3.5 to web server **158** executing on processor **130**.

In some embodiments, as discussed above, PBX/Ethernet module **100** may be installed and configured to appear to be an Ethernet adapter to a computing device **102** via the bus interface **124**. Accordingly, in many of these embodiments, an operating system of computing device **102** may direct network communications of applications executing on computing device **102** to PBX/Ethernet module **100**.

Furthermore, in some such embodiments, a virtual operating system or virtual machine executing on computing device **102** may direct network communications of virtualized applications to PBX/Ethernet module **100**. Such virtual operating systems or virtual machines may include a VMware virtual machine, using software provided by VMware, Inc. of Palo Alto, Calif.; a Xen virtual machine, using software provided by XenSource, Inc. or various open-source developers; a Windows Virtual PC, Virtual Server, or Microsoft Hyper-V Server, using software provided by Microsoft Corp. of Redmond, Wash.; a XenDesktop virtual machine, using software provided by Citrix Systems, Inc. of Fort Lauderdale, Fla.; a Parallels virtual machine, using software provided by Parallels, Inc. of Schaffhausen, Switzerland; a Java or Perl virtual machine; or any other type and form of virtual operating system or virtual machine. Because the PBX/Ethernet module **100** may be visible as an Ethernet adapter to an application executing within a virtual machine or virtual operating system, said virtualized application may direct SIP traffic to SIP, PBX, HMP, and other applications of the PBX/Ethernet module **100** without requiring specialized driver/hardware installation for the virtual machine.

Processor **130** may also, in some embodiments, operatively connect to a digital signal processor or DSP **144**. DSP **144** may comprise hardware, software, or any combination of hardware and software for processing audio signals communicated over a switched telephone network. DSP **144** may comprise functionality for analog/digital signal conversion, arithmetic processing, hardware pipelining, or any other functionality useful in audio processing. In some embodiments, DSP **144** may act as an echo canceller or hybrid echo suppressor. In many embodiments, DSP **144** provides functionality to a PBX system provided by PBX proxy **146**, described below, such as fax and modem operations, voice transcoding, voice enhancement, noise reduction, noise shaping, packet loss concealment, audio compression, expansion, and gating, equalization, audio mixing, conferencing, and other features.

In some embodiments, PBX/Ethernet module **100** may comprise a PBX proxy **146**. PBX proxy **146** may comprise hardware and/or software components for providing a full function private branch exchange telephone system to one or more foreign exchange stations via FXS ports **126** and PSTN trunk lines via FXO ports **128**. In some embodiments, PBX proxy **146** may be controlled or configured by processor **130** executing a PBX application **154**. Although not illustrated, in many embodiments, PBX proxy **146** is executed by a co-processor, to off-load processing from processor **130**. PBX proxy **146**, along with DSP **144** and PBX application **154**, may provide PBX features to telephones connected to FXS ports **126**, including voice mail, music on hold, teleconferencing, intercom functionality, caller ID, direct dial, or other functions useful to users of a private branch exchange.

In many embodiments, PBX/Ethernet module **100** comprises a speech engine **148**. Speech engine **148** may comprise any combination of hardware and software for voice recognition, speech-to-text processing, and text-to-speech processing. For example, in one embodiment, speech engine **148** provides a voice menu system for incoming calls from PSTN network **106**, with voice recognition to allow for selection of menu items and routing of the incoming calls.

PBX/Ethernet module **100** may comprise a power supply **150**. In many embodiments, power supply **150** receives power from a host computing device **102** via a bus interface **124**. In some embodiments, power supply **150** may convert these voltages to desired voltages for processor **130** or other components. For example, a PBX/Ethernet module **100** using a PCI interface may receive voltages provided by a power supply unit of computing device **102** via a backplane, including +3.3V or +5V, and power supply **150** may convert these voltages as desired, such as to +1.8V for low power flash RAM cards. Power supply **150** may further comprise functionality for dynamic voltage scaling for power management.

In some embodiments, power supply **150** may include additional components to allow conversion of AC voltages to desired DC levels. In such embodiments, a PBX/Ethernet module **100** may not require a host computing device **102** for operation.

PBX/Ethernet module **100** may execute an operating system **152**. In some embodiments, operating system **152** may be a desktop or server operating system, including any of the Windows variants manufactured by Microsoft Corp. of Redmond, Wash.; Unix, or a Unix-like operating system, including Gnu, Linux, or BSD; or a proprietary system, such as HP-UX, manufactured by Hewlett-Packard of Palo Alto, Calif., or AIX, manufactured by IBM of Armonk, N.Y. In some embodiments, the operating system **153** may be a firmware based or embedded operating system. In other embodiments, the PBX/Ethernet module may include any elements or combination of element of a computing device described below.

In some embodiments, PBX/Ethernet module **100** may execute any type and form of application, such as any one of several applications, including a PBX application **154**, an HMP application **156**, a web server **158**, and a SIP proxy **160**. In some embodiments, a PBX application **154** may provide configuration and functionality for the various functions of PBX proxy **146**, speech engine **148**, and DSP **144** discussed above. In some embodiments, an HMP application **156** may provide configuration and functionality for host media processing, including transcoding, vocoding, compression, buffering, automatic gain control and volume control, time-scale modification, and other signal processing functionality.

In many embodiments, processor **130** may execute a web server **158**. The web server **158** may serve web pages to a user of computing device **102** or another computer that can access PBX/Ethernet module **100** through a network, for the purpose of configuration, diagnostics, monitoring, and maintenance of various functions of PBX/Ethernet module **100**.

In some embodiments, processor **130** may execute a session initiation protocol (SIP) proxy **160**. SIP proxy **160** may comprise a SIP proxy server for performing the functionality of routing SIP requests between a plurality of clients. In many embodiments, SIP proxy **160** may comprise a SIP registrar and/or a redirect server for directing SIP session invitations to external domains. For example, SIP proxy **160** may provide location services registering one or more IP addresses to a SIP uniform resource identifier (URI). In some embodiments, SIP proxy **160** may comprise a user agent server and/or user age client for managing an SIP session or transaction. In many embodiments, SIP proxy **160** may comprise a media proxy for managing audio and/or video communications via a real-time transport protocol (RTP) and/or RTP control protocol (RTCP). In some embodiments, SIP proxy **160** may be executed by a second processor **130** or a co-processor, not illustrated.

Referring ahead to FIG. **1**E, in a further embodiment, a PBX/Ethernet module **100** may include an interconnection **192** to a DSP resource module **190**. DSP resource module **190** may be similar to a PBX/Ethernet module **100**, and include a processor **130'**, memory **132'**, RAM **134'**, a flash memory interface **136'**, a bus interface **124'**, and a power supply **150'**. A DSP resource module **190** may further comprise one or more DSPs **144***a*-**144***n* and a connection **192'** to PBX/Ethernet module **100**. For example, a PBX/Ethernet module **100** may include a connector **192** for an application, such as a PBX proxy, executing on a coprocessor to connect to one or more DSPs **144***a*-**144***n* on a DSP resource module **190** for additional processing capability. Thus, a DSP resource module **190** may provide expandability of a PBX/Ethernet system for reduced cost.

In some embodiments, connections between interboard connection **192** and **192'** may be via a parallel or serial connector, such as a multi-wire planar cable, a flexible flat cable, an ISA, PCI, PCI-X or other type of bus, or any other interface for communication between two modules of a system.

FIGS. **1**C and **1**D depict block diagrams of a computing device **102** useful for practicing an embodiment of the computing device **102** of FIG. **1**A, VOIP computers **114***a*-**114***b*, VOIP provider **118**, or any of the other computing devices shown in FIG. **1**A. As shown in FIGS. **1**C and **1**D, each computing device **102** includes a central processing unit **130**, and a main memory unit **134**. As shown in FIG. **1**C, a computing device **102** may include a visual display device **162**, a keyboard **164** and/or a pointing device **166**, such as a mouse. Each computing device **102** may also include additional optional elements, such as one or more input/output devices **168***a-n* (generally referred to using reference numeral **168**), and a cache memory **170** in communication with the central processing unit **130**.

The central processing unit **130** is any logic circuitry that responds to and processes instructions fetched from the main memory unit **134**. In many embodiments, the central processing unit is provided by a microprocessor unit, such as: those manufactured by Intel Corporation of Mountain View, Calif.; those manufactured by Motorola Corporation of Schaumburg, Ill.; those manufactured by Transmeta Corporation of Santa Clara, Calif.; the RS/6000 processor, those manufactured by International Business Machines of White Plains, N.Y.; or those manufactured by Advanced Micro Devices of Sunnyvale, Calif. The computing device **102** may be based on any of these processors, or any other processor capable of operating as described herein.

Main memory unit **134** may be one or more memory chips capable of storing data and allowing any storage location to be directly accessed by the microprocessor **130**, such as Static random access memory (SRAM), Burst SRAM or SynchBurst SRAM (BSRAM), Dynamic random access memory (DRAM), Fast Page Mode DRAM (FPM DRAM), Enhanced DRAM (EDRAM), Extended Data Output RAM (EDO RAM), Extended Data Output DRAM (EDO DRAM), Burst Extended Data Output DRAM (BEDO DRAM), Enhanced DRAM (EDRAM), synchronous DRAM (SDRAM), JEDEC SRAM, PC100 SDRAM, Double Data Rate SDRAM (DDR SDRAM), Enhanced SDRAM (ESDRAM), SyncLink DRAM (SLDRAM), Direct Rambus DRAM (DRDRAM), or Ferroelectric RAM (FRAM). The main memory **134** may be based on any of the above described memory chips, or any other available memory chips capable of operating as described herein. In the embodiment shown in FIG. **1**C, the processor **130** communicates with main memory **134** via a system bus **172** (described in more detail below). FIG. **1**D depicts an embodiment of a computing device **102** in which the processor communicates directly with main memory **134** via a memory port **174**. For example, in FIG. **1**F the main memory **134** may be DRDRAM.

FIG. **1**D depicts an embodiment in which the main processor **130** communicates directly with cache memory **170** via a secondary bus, sometimes referred to as a backside bus. In other embodiments, the main processor **130** communicates with cache memory **170** using the system bus **172**. Cache memory **140** typically has a faster response time than main memory **122** and is typically provided by SRAM, BSRAM, or EDRAM. In the embodiment shown in FIG. **1**F, the processor **130** communicates with various I/O devices **168** via a local

system bus **172**. Various busses may be used to connect the central processing unit **130** to any of the I/O devices **168**, including a VESA VL bus, an ISA bus, an EISA bus, a MicroChannel Architecture (MCA) bus, a PCI bus, a PCI-X bus, a PCI-Express bus, or a NuBus. For embodiments in which the I/O device is a video display **162**, the processor **130** may use an Advanced Graphics Port (AGP) to communicate with the display **162**. FIG. **1**D depicts an embodiment of a computer **102** in which the main processor **130** communicates directly with I/O device **168***b* via HyperTransport, Rapid I/O, or InfiniBand. FIG. **1**D also depicts an embodiment in which local busses and direct communication are mixed: the processor **130** communicates with I/O device **168***b* using a local interconnect bus while communicating with I/O device **168***a* directly.

The computing device **102** may support any suitable installation device **174**, such as a floppy disk drive for receiving floppy disks such as 3.5-inch, 5.25-inch disks or ZIP disks, a CD-ROM drive, a CD-R/RW drive, a DVD-ROM drive, tape drives of various formats, USB device, hard-drive or any other device suitable for installing software and programs such as any client agent **176**, or portion thereof. The computing device **102** may further comprise a storage device **132**, such as one or more hard disk drives or redundant arrays of independent disks, for storing an operating system and other related software, and for storing application software programs such as any program related to the client agent **176**. Optionally, any of the installation devices **174** could also be used as the storage device **132**. Additionally, the operating system and the software can be run from a bootable medium, for example, a bootable CD, such as KNOPPIX®, a bootable CD for GNU/Linux that is available as a GNU/Linux distribution from knoppix.net.

Furthermore, the computing device **102** may include a network interface or NIC **142** to interface to a Local Area Network (LAN), Wide Area Network (WAN) or the Internet through a variety of connections including, but not limited to, standard telephone lines, LAN or WAN links (e.g., 802.11, T1, T3, 56kb, X.25), broadband connections (e.g., ISDN, Frame Relay, ATM), wireless connections, or some combination of any or all of the above. The network interface **142** may comprise a built-in network adapter, network interface card, PCMCIA network card, card bus network adapter, wireless network adapter, USB network adapter, modem or any other device suitable for interfacing the computing device **102** to any type of network capable of communication and performing the operations described herein. A wide variety of I/O devices **168***a*-**168***n* may be present in the computing device **100**. Input devices include keyboards, mice, trackpads, trackballs, microphones, and drawing tablets. Output devices include video displays, speakers, inkjet printers, laser printers, and dye-sublimation printers. The I/O devices **168** may be controlled by an I/O controller **178** as shown in FIG. **1**C. The I/O controller may control one or more I/O devices such as a keyboard **164** and a pointing device **166**, e.g., a mouse or optical pen. Furthermore, an I/O device may also provide storage **132** and/or an installation medium **174** for the computing device **102**. In still other embodiments, the computing device **102** may provide USB connections to receive handheld USB storage devices such as the USB Flash Drive line of devices manufactured by Twintech Industry, Inc. of Los Alamitos, Calif.

In some embodiments, the computing device **102** may comprise or be connected to multiple I/O devices **168***a*-**168***n* or one or more display devices **162**, which each may be of the same or different type and/or form. As such, any of the I/O devices **168***a*-**168***n* and/or the display devices **162** or I/O controller **178** may comprise any type and/or form of suitable hardware, software, or combination of hardware and software to support, enable or provide for the connection and use of multiple I/O devices **168***a*-**168***n* or display devices **162** by the computing device **102**. For example, the computing device **102** may include any type and/or form of video adapter, video card, driver, and/or library to interface, communicate, connect or otherwise use the display devices **162**. In one embodiment, a video adapter may comprise multiple connectors to interface to multiple display devices **162**. In other embodiments, the computing device **102** may include multiple video adapters, with each video adapter connected to one or more of the display devices **162**. In some embodiments, any portion of the operating system of the computing device **102** may be configured for using multiple display devices **162**. In other embodiments, one or more of the display devices **162** may be provided by one or more other computing devices via a network.

In further embodiments, an I/O device **168** may be a bridge **180** between the system bus **172** and an external communication bus, such as a USB bus, an Apple Desktop Bus, an RS-232 serial connection, a SCSI bus, a FireWire bus, a FireWire 800 bus, an Ethernet bus, an AppleTalk bus, a Gigabit Ethernet bus, an Asynchronous Transfer Mode bus, a HIPPI bus, a Super HIPPI bus, a SerialPlus bus, a SCI/LAMP bus, a FibreChannel bus, or a Serial Attached small computer system interface bus.

A computing device **102** of the sort depicted in FIGS. **1**C and **1**D typically operate under the control of operating systems, which control scheduling of tasks and access to system resources. The computing device **102** can be running any operating system such as any of the versions of the Microsoft® Windows operating systems, the different releases of the Unix and Linux operating systems, any version of the Mac OS® for Macintosh computers, any embedded operating system, any real-time operating system, any open source operating system, any proprietary operating system, any operating systems for mobile computing devices, or any other operating system capable of running on the computing device and performing the operations described herein. Typical operating systems include: WINDOWS 3.x, WINDOWS 95, WINDOWS 98, WINDOWS 2000, WINDOWS NT 3.51, WINDOWS NT 4.0, WINDOWS CE, and WINDOWS XP, all of which are manufactured by Microsoft Corporation of Redmond, Washington; MacOS, manufactured by Apple Computer of Cupertino, Calif.; OS/2, manufactured by International Business Machines of Armonk, N.Y.; and Linux, a freely-available operating system distributed by Caldera Corp. of Salt Lake City, Utah, or any type and/or form of a Unix operating system, among others.

In other embodiments, the computing device **102** may have different processors, operating systems, and input devices consistent with the device. For example, in one embodiment the computer **102** is a Treo 180, 270, 1060, 600 or 650 smart phone manufactured by Palm, Inc. In this embodiment, the Treo smart phone is operated under the control of the PalmOS operating system and includes a stylus input device as well as a five-way navigator device. Moreover, the computing device **102** can be any workstation, desktop computer, laptop or notebook computer, server, handheld computer, mobile telephone, any other computer, or other form of computing or telecommunications device that is capable of communication and that has sufficient processor power and memory capacity to perform the operations described herein.

Referring now to FIG. **2**, shown is a block diagram of an embodiment of a system for communicating with an interface module for a mixed switched and IP telecommunications

environment. Briefly, a client application **200** communicates via a client agent **202** with a PBX/Ethernet module **100** by using function calls **228** and application callbacks **230**. In some embodiments, client agent **202** may comprise a parser **204**, a message generator **206**, a communication manager **208**, and a callback generator **210**. In some embodiments, communication manager **208** may comprise an encryption/decryption module **234**. Communication manager **202** may transmit and receive network messages **232** from various components of a PBX/Ethernet module **100**, including a TDM gateway **212**, a video gateway **214**, a fax gateway **216**, DSP **218**, a PBX proxy **220**, an HMP server **222**, a speech engine **224**, and an SIP proxy **226**. In some embodiments, client agent **202** serves as an application programming interface for components of PBX/Ethernet module **100** to allow for easy and consistent programming by application developers.

Still referring to FIG. **2** and in more detail, a client application **200** may be executed by a computing device **102**, VOIP computer **114**, or any other computing device able to communicate via a network with PBX/Ethernet module **100**. Client application **200** may comprise an application, a service, a routine, an executable program, a daemon, or any other type and form of executable instructions, such as instructions for interacting and controlling a communications module of PBX/Ethernet module **100**. In many embodiments, client application **200** may comprise a web browser, a VOIP interface, a fax manager, a video teleconferencing interface, or other similar application.

Client agent **202** may comprise a service, a routine or subroutine, a function, an API, an executable program, a daemon, a run-time environment, a set of commands, or any other type and form of executable instructions, such as instructions for providing function calls and application callbacks to an application, and transmitting, receiving and interpreting network communications messages, such as via modules of a PBX/Ethernet module **100**. In some embodiments, client agent **202** may receive a function call **228** from a client application, and parse the function call to generate a network message **232**. Client agent **202** may transmit the network message via any type and form of network layer interface, such as a layer 2-4 interface via Ethernet, to PBX/Ethernet module **100**. For example, the client agent may establish transport layer connections using sockets (e.g. layer 4 interfaces), such as via TCP over IP or UDP over IP. Client agent **202** may also receive a network message **232** from PBX/Ethernet module **100** and parse the message to generate an application callback **230**, which may be passed to the application.

In many embodiments, a client application **200** may send functional calls and receive callbacks without being aware that a resource is non-local or accessed via a network. By separating the application from the network communication, application developers need not know about network protocols, communications sockets, handshaking procedures, message acknowledgements, and other features common to network communications. In some embodiments, an application may send a function call to a resource without specifying a network identifier or address of the resource, and the client agent may determine the identifier or address and generate a corresponding network communication as necessary. For example, the application may only need to know the name of the resource and not the IP address of the resource. In many embodiments, an application may use blocking function calls transmitted via client agent **202** over a network without tying up a network interface or preventing other applications from using the network interface.

In another aspect, the client agent makes a local non-LAN based API LAN and network aware but does so transparently and/or seamlessly to the application using the local non-LAN API layer. The client agent may seamlessly and transparently translate, convert or process a local procedural, imperative or functional API call of the application to one or more network reply and response messages using socket based communications such as TCP over IP or UDP over IP. In some aspects, even if the developer or application is aware that the client agent is performing network based communications and protocols, the developer and/or applications does not need knowledge of the mechanisms, protocols and interfaces for such network based communications.

Application providers are experts in their application areas such as voice processing, easy to use interfaces, call flow handling amongst others but may not necessarily be experts or knowledgeable on the behavior of networks that they run on. The client side API systems and method described herein allow application vendors and developed to focus on the application and use the power of an Ethernet based system to intercommunicate with many communications systems. This will allow application vendors and developed to focus on applications and yet have the power to have resources for trans-coding, termination and communications from numerous systems. In providing such a system the application vendors will not have to create a framework and communication protocol which will decrease their engineering budget requirements for their client/server applications which will also rapidly increase their time to market and reduce the risk in the development of the solution.

In some embodiments, client agent **202** may comprise a parser **204**. A parser **204** may comprise a service, a routine or subroutine, a function, an executable program, a daemon, a set of commands, or any other type and form of executable instructions for interpreting function calls **228** and network messages **232**. In some embodiments, a parser **204** may extract one or more functions, parameters and/or variables from a function call **228** and/or a network message **232**. For example, a function call **228** may comprise a function indicating to start a new communication session with a resource, and variables indicating to login via an application name, a password, and an indication to use encryption. In another example, a function call **228** may comprise a function indicating to create a communications session between a VOIP client on a network and a PSTN circuit, and send a sequence of DTMF dialing tones on the PSTN circuit via a PBX module, and include variables of the DTMF tones. In another example, parser **204** may parse a network message **232** to identify a target application based on an IP address, port number, sequence number, or any other identification in a header or payload, and parse a payload of the message to identify an application callback to generate and one or more parameters to include in said callback.

A message generator **206** may comprise a service, a routine or subroutine, a function, an executable program, a daemon, a set of commands, or any other type and form of executable instructions for generating a network message responsive to parsed functions and variables in a function call **228**. In some embodiments, a message generator **206** may comprise a table of resources and/or remote devices and corresponding network identifiers or addresses. In other embodiments, a message generator **206** may comprise functionality for determining a resource's network identifier through queries or domain identifiers. In some embodiments, a message generator **206** may create a network message having a header identifying a target resource or device's network address or identifier and

having a payload comprising a function and/or parameters parsed from a functional call **228**.

A communication manager **208** may comprise a service, a routine or subroutine, a function, an API, an executable program, a daemon, a run-time environment, a set of commands, or any other type and form of executable instructions for transmitting and receiving network messages **232**. In some embodiments, a communication manager **208** may comprise a network driver or adapter, such as an Ethernet adapter. In some embodiments, a communication manager **208** may comprise or communicate with a hardware network interface, such as a NIC. In many embodiments, a communication manager **208** may comprise additional functionality for secure communications, including an encryption/decryption module **234**. In these embodiments, a communication manager **208** may encrypt and decrypt communications using various encryption methods or algorithms. In some embodiments, a communication manager **208** further comprises functionality for compressing and decompressing communications.

A callback generator **210** may comprise a service, a routine or subroutine, a function, an executable program, a daemon, a set of commands, or any other type and form of executable instructions for generating an application callback **230** responsive to a received and parsed network message **232**. In some embodiments, a callback generator **210** comprises a callback table or database, and generates application callbacks responsive to entries within the callback table. For example, in one such embodiment, a callback generator **210** may receive a parsed network message **232** indicating that an event, such as an incoming call, has occurred, along with variables or parameters, such as a call source and destination. The callback generator **210** may create a callback to a client application **200** in a predetermined format specified by the callback table and pass the callback to client application **200**. In some embodiments, the predetermined formats specified by the callback table allow application developers to create applications with functions executed responsive to the various predetermined callbacks.

As shown in FIG. **2**, network messages **232** may be transmitted to and received from various modules or components of a PBX/Ethernet module **100**, including a time-domain multiplexing (TDM) gateway **212**, a video gateway **214**, a fax gateway **216**, a digital signal processor **218**, a private branch exchange proxy **220**, a host media processing server **222**, a speech engine **224**, a session initiation protocol proxy **226**, or any other component or module of a PBX/Ethernet module **100**. In some embodiments, a communication may be directed to one of these modules by a network switch executing on PBX/Ethernet module **100**, responsive to contents of a header and/or payload of the communication. For example, communications with a first destination port number may be directed to a TDM Gateway **212**, while communications with a second destination port number may be directed to a PBX proxy **220**. In another example, communications with a payload in a first application layer protocol may be directed to a video gateway **214**, while communications with a payload in a second application layer protocol may be directed to a fax gateway.

Shown in FIG. **3**A is a signal flow diagram of an embodiment of a client agent utilizing an application programming interface (API) between a client application and a host media processing (HMP) system. Briefly, a client application **300** registers callbacks **308** with a client agent **302** using an API protocol **304**. The client application **300** passes a request **310** to the client agent **302**, which generates a command **312** and transmits the command **312** to an HMP **306**. The HMP generates a response **314**. HMP **306** generates one or more events **316***a*-**316***n* and transmits them to the client API **302**, which parses each event and generates an application callback **318***a*-**318***n*. Many embodiments of API function call/callback interactions do not involve acknowledgements, unlike many network communication protocols. Similarly, many embodiments of API function call/callback interactions use blocking function calls, in which a client application stalls and waits for a response until a response is received, again unlike many network communications protocols. The client agent **302** thus serves as a translator between a blocking function call/callback interaction with an application and a network communication involving requests and acknowledgements with a remote device. In some embodiments, client agent **302** also serves as a multiplexer between multiple applications such that a network interface is not tied up by a blocking function call while waiting for a response from a remote device.

Still referring to FIG. **3**A and in more detail, at **308**, a client application **300** may register callbacks with a client agent **302** using an API protocol **304**. Registering a callback allows an application to specify one or more callbacks **318** to be invoked in response to one or more events **316**, and provide arguments for callback parameters.

As is shown in FIG. **3**A, some responses from a remote device, such as a host media processing server **306** may be discarded rather than being translated into a callback **318** to client application **300**. In some embodiments, discarded responses may include acknowledgements. For example, in a network communication involving a request/acknowledgement protocol such as TCP, a client may transmit a request to a remote device and the remote device may respond with an acknowledgement of the request being received. Because the acknowledgement only indicates receipt of the request, rather than a response to the content of the request, the acknowledgement may not be useful to a client application **300**. Accordingly, the client agent **302** may discard the acknowledgement. In other embodiments, duplicate responses may be received, for example due to losses of acknowledgements that trigger retransmittals. In one such embodiment, duplicate responses may be discarded. Once appropriate processing or other functions have been performed, the remote device may transmit a response or an event to the client agent **302**, which may generate appropriate callbacks for the client application **300**.

In some embodiments, a command **312** may direct a remote device, such as a host media processor **306** to initiate various functions, such as a voice telephone call. Accordingly, once initiated, further communications may occur from the host media processor, such as an indication of a busy signal or a call being dropped or various other telephony events. Accordingly, events **316** may be generated and transmitted to the client. Client agent **302** may parse the events and generate appropriate callbacks **318** responsive to each event.

Shown in FIG. **3**B is a block diagram of an embodiment of an API between a client application and an HMP system. In brief overview, a client application **300** passes a request **310** to a client agent **302**. In some embodiments, a formatter **320** formats the command into a network message, and an encryption module **322** encrypts the command for secure transmittal. Communication manager **208** transmits the command **312** to an HMP system **306**. HMP **306** transmits a response **314** which is received by communication manager **208**. In some embodiments, the response is decrypted in a decryption module **324**. A parser **326** retrieves parameters from the

response. The client agent **302** may pass the parameters to the application **300** and/or update application data **328** and callback table **330**.

Referring ahead to FIG. **3**C, another block diagram of an embodiment of an API between a client application and an HMP system is shown. Briefly, an HMP **306** sends an event **316** via a network communication to a communication manager **208**, which queues the event as necessary in a queue **332**. Parser **326** retrieves parameters of the event and updates application data **328**. In some embodiments, using a callback table **330**, the parser **326** generates an application callback **318** and passes the callback to the client application **300**. FIG. **3**B illustrates command/response flow, while FIG. **3**C illustrates an independent queue for event processing. Utilizing independent queues allows for asynchronous event handling in a multi-threaded system.

Returning to FIG. **3**B, a formatter **320** may comprise a service, a routine or subroutine, a function, an executable program, a daemon, a set of commands, or any other type and form of executable instructions for parsing and processing requests. In some embodiments, a formatter **320** may comprise functionality for mapping a request to a command, validating input parameters of the request, and/or generating a command message.

In some embodiments, network messages may optionally be encrypted **322** before transmission and decrypted **324** after receipt. This may be useful in embodiments in which command and configuration messages travel via a public network where a malicious attacker can intercept and regenerate commands. In some embodiments, network messages may be compressed and decompressed to reduce network bandwidth, if necessary.

A communication manager **208**, as discussed above, may handle transmission and receipt, queuing, buffering, and other functionality as necessary or desired for processing network communications between the client and a remote device or module. Once received, responses **314** are decrypted and/or decompressed, and passed to parser **326**. As discussed above as parser **204** of FIG. **2**, a parser comprises functionality for extracting arguments and parameters from a response **314**. In some embodiments, parser **326** updates application data **328** responsive to the parameters in response **314**. Application data **328** may comprise a local mirror of host media processing data related to resources used by client application **300**. In many embodiments, parser **326** generates a callback or modifies an entry in a callback table **330** responsive to parameters in response **314**.

Returning to FIG. **3**C, events may be generated by a remote device such as HMP **306** and notifications of an event **316** may be transmitted via a network communication. Where a blocking function call will stall an application until a response is received such that only one function call and response are communicated between an application and remote device at a time, multiple events may be sent by the remote device within a short time period. Thus, to allow for processing of events in order, in some embodiments, a queue **332** may be used to hold messages until a parser **326** is available to process the event message. In one embodiment, processing an event message may comprise extracting parameters and arguments from the payload of a network message, the parameters and arguments identifying an event and/or additional details of the event. In some embodiments, retrieving a corresponding callback from callback table **330** that was registered by the client application **300** for the event. In some embodiments, parser **326** may update application data **328** responsive to parameters of the event. In many embodiments, parser **326** may pass the retrieved application callback, including any parameters of the event message, to the client application **300**.

FIG. **4**A is a flow chart of an embodiment of a method for accessing private branch exchange services via a single integrated device installed as an Ethernet adapter on a computing device. In brief overview, at step **400**, a PBX/Ethernet module may receive a network communication. A network switch of the module may determine, at step **402**, if the communication is directed to a local component or application executing on the module, or outbound to the network. If the communication is local, then at step **404**, the switch may direct the communication to a target component. At step **406**, the target component may process the communication. If the communication is directed outbound to the network, then at step **408**, the switch may direct the communication to an outbound interface.

Still referring to FIG. **4**A and in more detail, at step **400**, a PBX/Ethernet module may receive a network communication. In one embodiment, the PBX/Ethernet module may receive a network communication from a host computing device via a bus interface. In one embodiment in which the PBX/Ethernet module is serving as a network adapter for the host computing device, the network communication may be an application layer, presentation layer, or session layer communication via an API or other interface. In a further embodiment, the PBX/Ethernet module may add transport layer and/or network layer headers to the communication to allow the message to be transmitted via a network. In another embodiment, the PBX/Ethernet module may receive the network communication via a network interface.

At step **402**, an Ethernet switch of the PBX/Ethernet module may determine if the communication is directed locally to a component or module of the PBX/Ethernet module, or directed outbound. As used herein, outbound refers to a destination external to PBX/Ethernet module, but such destination may be on a network connected to a network port of the PBX/Ethernet module, or may be a host computing device connected to a bus interface of the PBX/Ethernet module. Thus, in an embodiment in which the PBX/Ethernet module is serving as a network adapter for a host computing device, a communication received by the PBX/Ethernet module from another network device and redirected to the host computing device may be considered to be redirected outbound to the host computing device. In some embodiments, a determination of whether the communication is directed locally or directed outbound may be responsive to a destination IP address or port number of the communication. In another embodiment, the determination may be made responsive to a protocol of the communication. In one such embodiment, a communication may be directed outbound if it includes a payload in a protocol that the PBX/Ethernet module does not use. For example, if the PBX/Ethernet module is not executing a mail server, then a determination may be made that a communication with an IMAP or POP protocol payload is directed outbound.

At step **404**, the switch may direct the communication to an appropriate module or component of the PBX/Ethernet module, such as a PBX application or an HMP application, a speech engine or a DSP resource, a processor or co-processor, a web server, a SIP proxy, or any other module or component of the PBX/Ethernet module, as described above. In some embodiments, the switch may direct the communication responsive to a characteristic of the communication, such as a port number or protocol of the communication.

At step **406**, the module or component may process the communication. In many embodiments, processing the com-

munication is responsive to the contents of the communication, such as a request or query. In some embodiments, processing the communication by a module or component may comprise executing a function of said module or component. For example, a PBX application may process the network communication to provide a PBX function, or an HMP application may provide an HMP function on a payload of a communication. In other embodiments, processing the communication may comprise modifying or reconfiguring the module or component. For example, a communication may change a compression parameter of a DSP resource, such that the DSP resource processes an audio or video signal differently. In some embodiments, processing the communication may comprise generating a response to the communication and sending the response to the switch.

If at step **402**, the switch determines that the communication is not directed to a local component or module of the PBX/Ethernet module, then at step **408**, the switch may direct the communication to an outbound interface. In some embodiments where the communication is received from a network interface of the PBX/Ethernet module, directing the communication to an outbound interface may comprise directing the communication to a bus interface. In other embodiments where the communication is received from a bus interface of the PBX/Ethernet module, directing the communication to an outbound interface may comprise directing the communication to a network interface. In still other embodiments where the communication is received from a local module or component of the PBX/Ethernet module, then directing the communication to an outbound interface may comprise directing the communication to either a network interface, a bus interface, or both a network interface and a bus interface, responsive to a header and/or a payload of the communication. For example, a broadcast communication may be sent to both interfaces.

Shown in FIG. **4**B is a flow chart of an embodiment of a method for providing a client-side application programming interface to access a networked telecommunication resource. Briefly, at step **420**, a client agent may receive a request from an application to perform a function. At step **422**, the client agent may establish a transport layer connection with a remote device. At step **424**, the client agent may parse the request, and at step **426**, the client agent may generate an application message. The client agent may transmit the message at step **428**. In some embodiments, the client agent may receive a response from the remote device at step **430**, and may return a callback to the application at step **432**.

Referring to FIG. **4**B and in more detail, at step **420**, a client agent may receive a request from an application to perform a function. In some embodiments, the client agent may receive a request via a local application interface call. In many embodiments, the client agent may receive a blocking API call. In some embodiments, the request to perform a function may be a request to perform a function via a telecommunication resource. However, in a further embodiment, the request to perform a function via the telecommunication resource may not identify the location of the resource, or even indicate that the resource is not local to the client. For example, in one such embodiment, an application may pass a blocking call to the client agent to execute a PBX function, but the call may not identify that the PBX function is to be performed by a PBX/Ethernet module accessible via a network connection. In many embodiments, the application may not be network aware, or may be agnostic to a network.

At step **422**, in some embodiments, the client agent may establish a transport layer connection with a remote device. In some embodiments, the client agent may utilize an already established transport layer connection, while in other embodiments, the client agent may establish a new transport layer connection. In many embodiments in which the request received at step **422** does not identify a resource by location, the client agent may determine a network identifier, such as an IP address and port, of the resource. In one embodiment, the client agent maintains a configuration, such as a file, table or database, of network identifiers of one or more resources. In some embodiments, establishing a transport layer connection may comprise performing a handshake routine, such as the three-way handshake of the TCP protocol.

Furthermore, although referred to as a remote device, in some embodiments, the remote device may be a module of a PBX/Ethernet module installed in a computing device as discussed above. Thus, establishing a transport layer connection with a remote device may comprise establishing a transport layer connection between a computing device and a PBX/Ethernet module installed to a bus of the computing device. For example, if the computing device is executing the client agent, the PBX/Ethernet module may still be considered to be a "remote" device, in spite of being installed as an Ethernet adapter in the computing device. Accordingly, one of ordinary skill in the art may understand that "remote" should not be read as implying geographical distance, or even network distance, but rather that a remote device is a device accessible to the client agent via a network connection.

At step **424**, the client agent may parse the received request. In some embodiments, parsing the request may comprise determining a requested resource from the request. Although illustrated as after step **422**, in many embodiments, step **424** may be performed prior to step **422**. For example, in one embodiment, a client agent may receive a request and parse the request to determine a target resource of the request. The client agent may then establish a transport layer connection with the target resource.

At step **426**, in some embodiments, the client agent may generate an application message corresponding to the local application interface call. In one embodiment, generating the application message may comprise creating a header and payload of a network message, with the header identifying a network identifier of a target resource, and a payload comprising the request in a format and/or protocol useable by the target resource. In one embodiment, generating the application message may comprise generating an ASCII message from parameters of the local API call. In some embodiments, generating the application message may comprise performing additional processing on the payload of the message, including compression and/or encryption. For example, in one such embodiment, the client agent may receive an API call with a request to modify parameters of a resource. The client agent may determine the network identifier of the resource and extract the parameters from the API call. The client agent may generate a network communication to an IP address and port number of the resource, with an encrypted payload comprising the extracted parameters of the request, for secure transmission over a public network.

At step **428**, the client agent may transmit the generated message to the remote device or resource over the transport layer connection. In some embodiments, transmitting the generated message may comprise transmitting the application message via a telecommunications protocol over the transport layer connection to the remote device. For example, in one such embodiment, the message may be transmitted via an SIP or TCP protocol.

At step **430**, the client agent may receive a response from the remote device or resource via the network. In some embodiments, the client agent may receive the response with

an encrypted and/or compressed payload. In a further embodiment, the client agent may decrypt and/or decompress the payload.

At step **432**, the client agent may return a local application interface call based on the response to the client application. In one embodiment, the client agent may parse the payload of the response to extract parameters sent responsive to the request. In a further embodiment, the client agent may generate the local application interface call or callback based on the extracted parameters. In some embodiments, the client agent may generate the call based on a callback table that identifies a callback for a request, and include parameters extracted from the payload of the response. In some embodiments, in which a plurality of client applications interact with the client agent concurrently to transmit API requests, the client agent may parse the header and/or payload of the response to identify the client application that initiated the request corresponding to the response.

Although not illustrated, in some embodiments, the client agent may receive one or more network communications or packets transmitted by the remote device or resource. In these embodiments, the client agent may generate corresponding application or event calls based on event parameters in the payload of the one or more network communications and pass the application or event calls to the client application.

While various embodiments of the methods and systems have been described, these embodiments are exemplary and in no way limit the scope of the described methods or systems. Those having skill in the relevant art can effect changes to form and details of the described methods and systems without departing from the broadest scope of the described methods and systems. Thus, the scope of the methods and systems described herein should not be limited by any of the exemplary embodiments and should be defined in accordance with the accompanying claims and their equivalents.

What is claimed:

1. A method for providing a client-side application programming interface to access a networked telecommunication resource, the method comprising:

(a) receiving, by an agent executing on a client device, via a local application interface call from a client application a request to perform a function via a telecommunication resource;

(b) establishing, by the agent, a transport layer connection via a network to the remote device identified by the agent as providing the telecommunication resource;

(c) generating, by the agent, an application message corresponding to the local application interface call;

(d) transmitting, by the agent, the application message over the transport layer connection via the network to the remote device;

(e) receiving, by the agent, a response to the application message via the network from the telecommunication resource of the remote device; and

(f) returning, by the agent, a result to the local application interface call based on the response.

2. The method of claim **1**, wherein step (a) further comprises receiving, by the agent, a local API call from a client application that is not network aware.

3. The method of claim **1**, wherein step (b) further comprises determining, by the agent, a network identifier for the telecommunication resource identified by the local application interface call.

4. The method of claim **1**, wherein step (c) further comprises generating for the application message an ASCII message from parameters of the local API call.

5. The method of claim **1**, wherein step (c) further comprises encrypting, by the agent, the application message.

6. The method of claim **1**, wherein step (d) further comprises transmitting, by the agent, the application message via a telecommunications protocol over the transport layer connection to the remote device.

7. The method of claim **1**, wherein step (e) further comprises parsing, by the agent, an application layer payload of the response to extract parameters.

8. The method of claim **1**, wherein step (e) further comprises decompressing, by the agent, an application layer payload of the response.

9. The method of claim **1**, wherein step (f) further comprises determining, by the agent, from content of an application layer payload of the response the result to return to the local API call.

10. The method of claim **1**, further comprising receiving, by the agent, an event via application layer data from one or more packets transmitted by the remote device to the agent.

11. The method of claim **1**, further comprising transmitting by the agent the application message and receiving the response via the network transparently to the client application.

12. A system for providing a client-side application programming interface to a telecommunication resource, the system comprising:

an agent executing on a client device receiving, via a local application interface call from a client application, a request to perform a function via a telecommunication resource;

a formatter of the agent formatting an application message corresponding to the local application interface call;

a communications manager of the agent establishing a transport layer connection via a network to the remote device identified by the agent as providing the telecommunication resource and transmitting the application message over the transport layer connection via the network to the remote device,

wherein the communications manager receives a response to the application message via the network from the telecommunication resource of the remote device; and

a parser of the agent parsing the response received from the communication manager,

wherein the agent returns a result to the local application interface call based on the parsed response.

13. The system of claim **12**, wherein responsive to a plurality of local API calls, the agent, transparently to the client application, transmits requests to one or more telecommunication resources over the network and receives responses over the network from the one or more telecommunication resources.

14. The system of claim **12**, wherein the communications manager determines a network identifier for the telecommunication resource identified for the local application interface call.

15. The system of claim **12**, wherein the formatter generates for the application message an ASCII message from parameters of the local API call.

16. The system of claim **12**, wherein an encryptor of the agent encrypts the application message.

17. The system of claim **12**, wherein a protocol manager transmits via the communications manager the application message via a telecommunications protocol over the transport layer connection to the remote device.

18. The system of claim **12**, wherein the parser parses an application layer payload of the response to extract parameters.

19. The system of claim **12**, wherein a decryptor decompresses an application layer payload of the response.

20. The system of claim **12**, wherein a protocol manager determines from content of an application layer payload of the response the result to return to the local API call.

21. The system of claim **12**, further comprising an events manager receiving from the communications manager an event via application layer data of one or more packets transmitted by the remote device and responsive to the event, the events manager executing one or more callbacks registered for the event.

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